Literature Search Related to the Impact of Distributed Generation on Emission Rates and Air Quality

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1. INTRODUCTION

Distributed generation (DG) is expected to play an increasingly important role in meeting future power generation needs. One question has been how displacing centrally generated power with distributed generation will impact the environment. The SCNG is developing two very clean distributed power technologies (fuel cells and turbines) that will be capable of meeting distributed power needs with very low emissions. However, many of the currently available distributed power generating technologies are dirtier than the central power that they may replace. To determine the impact of deploying distributed generation, the SCNG is planning to perform a study. The objective of the study will be to quantify changes in emission rates and air quality given various mixes of central and distributed power generation technologies.

In preparation for this study, Parsons conducted an Internet search to identify existing models, simulations, databases, or other analyses relevant to the impact of distributed generation on emission rates and air quality that were readily available. The results of this search were stored in a Microsoft Access database for easy retrieval. The database file has been included on the CD deliverable and contains a few example queries and reports used to summarize the information for this report.

While this search concentrated on the environmental impact of distributed generation, several other aspects were also explored. In addition to Environmental Issues, these aspects included Interconnection Issues, Market Issues, Regulatory Issues, Technologies, Operating Unit Data, Fuel Data, and General Sources. A field, Issue_Category, containing the topic(s) most addressed by each item has been included in the Survey_Results table in the database. Example queries for viewing items pertaining to these subjects are also included in the database.

In addition to specific literature items, three tables were created in the database for storing organizations, web sites, and publications that may be useful to someone conducting a similar search. Example queries and reports for retrieving this information were also included.

2. OBJECTIVE

The objective of the literature search was to answer the following questions:

1. Have similar analyses been performed? What were the findings?
2. What databases, analyses, or other relevant information are already available for use in the planned study?
3. Are there any models or simulation tools that are particularly suited for such an analysis?
4. Are there any gaps in the knowledge base that could provide the SCNG with an opportunity to generate information that would add to the knowledge base?

3. ENVIRONMENTAL ISSUES IDENTIFIED WITH DG

Distributed generation technologies can provide customers with energy solutions that are more cost-effective, more environmentally friendly, or provide higher power quality or reliability than conventional solutions. Some of these DG technologies offer high efficiency, resulting in low fuel costs, but emit a fair amount of pollutants (SO_2, NO_x, particulates, and CO); others are environmentally clean but are not currently cost-effective. DG technologies are currently being used for the niche applications. Many reports and studies predict that the market for DG technologies will continue to grow as their price and performance improves and energy markets deregulate.

The DG technologies include:

- Reciprocating engines
- Microturbines
- Industrial combustion turbines
- Fuel cells
- Photovoltaics
- Wind turbine systems

3.1 EMISSION CONTROL PRACTICE

Distributed generation embraces a wide range of technologies with a wide range of emissions. For fossil-fired distributed technologies, there are two key areas of concern: SO_2, NO_x, particulates, and CO emissions on local/regional air quality and greenhouse-gas emissions on climate change.

Emissions per kilowatt-hour of SO_2 and NO_x from distributed generation (except by diesel generators) tend to be lower than those from a coal-fired power plant or a utility system using a large proportion of coal. At the same time, the emission rates from existing distributed generation, except by fuel cells, photovoltaics (PV), and wind, are higher than the "best available" central generation: a combined-cycle gas turbine with advanced emissions control. This disadvantage puts a serious limitation on distributed generation in localized areas where SO_2, NO_x, particulates, and CO emissions are rigorously controlled, even when DG could reduce overall national or regional emissions sharply.

The case of carbon dioxide emissions is similar: Emissions rates for distributed generation are generally lower than those for coal plants, but not as low as those for new combined cycles, except for DG used in the combined heat and power (CHP) mode. Measures can be designed that encourage distributed generators to reduce emissions. The use of economic instruments like carbon-emissions trading, for example, would give DG operators an incentive to design and operate their facilities in ways that minimize emissions of greenhouse gases.

3.1.1 Reciprocating Engines

Reciprocating engines are represented by at least three types of equipment:

- Diesel engines, which burn fuel oils ranging from distillate oil (No. 2) to heavy bottoms (Bunker C). These engines operate on a compression ignition or diesel cycle, and do not utilize electrical sparking energy to achieve fuel ignition.

- Spark ignition engines, which burn a range of fuels from natural gas and propane to gasoline. This class of engines relies on electrical spark energy to ignite the fuel/air mixture.

- Dual fuel engines, which operate on the compression ignition cycle, but burn natural gas in lieu of the heavier hydrocarbons used in the conventional diesel engine described above. The dual fuel engines inject a small amount of pilot fuel (No. 2 oil) into the pre-combustion chamber at a specific point in the engine firing sequence. The pilot oil ignites and creates a flame front with tailored geometry that burns the natural gas and air mixture compressed in the engine's main combustion chamber. Pilot oil consumption ranges from 3 to 10% of total engine fuel input.

The combustion process produces NO_x and may also produce carbon monoxide, hydrocarbon, and particulate emissions. The combustion process also produces SO_2 from residual sulfur in the fuel. As a result, diesels are primarily being used for emergency or standby applications. Dual fuel engines offer an alternative that combines the efficiency and reliability of a diesel engine with the emission benefits of natural gas. These engines tend to produce lower NO_x and particulate emissions than diesel engines.

Add-on emission reducing controls can be incorporated on diesels, dual fuel units, and rich-burn natural gas engines, but siting remains difficult in severe or extreme ozone non-attainment areas. In addition, particulate traps may be required to control particulate matter emission from diesel engines. SO_2 emissions are purely a function of fuel characteristics and are primarily controlled by the amount of residual sulfur allowed in the fuel.

Newer lean-burn engines are superior for NO_x control, and often include modifications that allow for further reductions of emission levels. It should also be noted that engine manufacturers are developing techniques for reducing NO_x emissions from diesel engines. These techniques (water injection, catalytic NO_x reduction) have the potential to reduce NO_x output by 85 to 95% relative to uncontrolled engines. The newest engines on the market, equipped with NO_x and particulate reduction technology, can be considered candidates for distributed generation even in highly regulated areas.

3.1.2 Microturbines

In general, microturbine emissions are comparable to those of larger turbines. It is difficult to state exact emission levels as most microturbine emission data are based on manufacturer projections and claims, and must be confirmed by field testing. Emission control technologies in microturbines tend to focus on combustor design and flame control rather than technologies used in larger industrial turbines such as water/steam injection. However, because of their small size, these units tend to fall below most compliance requirement triggers. As a result, many microturbine installations have been exempt from emission regulations.

3.1.3 Combustion Turbines

Typically, emissions of combustion turbines are controlled in the combustion process. Wet controls, using water or steam injection to reduce the combustion temperature which, in turn, reduces NO_x levels, have been used for years. Usage of this control type is constrained by availability of a water supply and space for storage tanks. Dry low NO_x (DLN), conceptually similar to lean burn technology for reciprocating engines, creates a lean, homogeneous mixture of air and fuel that then enters the combustor. This minimizes hot spots and reduces the combustion temperature, which leads to lower NO_x levels. DLN has become the standard for NO_x control in combustion turbines.

The installed costs of combustion turbines differ greatly depending upon the emission control regulations in the region where they are sited. The installed cost in a lowest achievable emission rate (LAER) (strict emission control regulations) region that includes a selective catalytic reduction (SCR) unit is much higher than that in a non-LAER (some control) area, although this gap in pricing decreases as the unit size increases.

3.1.4 Fuel Cells, Photovoltaics, and Wind Turbines

Fuel cells produce little direct emissions. Photovoltaic and wind turbine systems produce no direct emissions.

3.2 ENVIRONMENTAL ISSUES

The permitting process for small-scale generators is much easier than that for larger generators, if even required at all. Stationary pollution sources below a defined size do not need a permit to operate, and microgenerators fit into that category. Their emission levels are also quite low, with fuel cells, photovoltaics, and wind turbines near zero.

Microgenerators such as fuel cells, photovoltaics, and microturbines have always been environmentally friendly, but now their decreasing cost is finally making their widespread deployment possible. Coupled with intelligent monitoring and control systems, these units can reduce the cost and environmental impact of electricity grids.

The evolving trend in the increasing size and use of DG has the potential to significantly undercut air quality gains for SO_2 and NO_x emissions and other pollutants achieved by central electric utilities and other major sources, if not carefully regulated.

NO_x emissions have been among the primary concern for DG utilizing turbines and engines. The NO_x emission rate from gas turbine options ranges from 0.3 to 1.0 lb/MWh, and NO_x emissions from central station fossil generation range from about 4 lb/MWh for plants with minimal controls to less than 1 lb/MWh for plants using selective catalytic control (SCR). This can be compared to a diesel engine emission rate of 12 lb/MWh (uncontrolled) to about 1 lb/MWh for engines using the most effective NO_x reduction technologies.

SO_2 emissions, which are a function of the fuel used, range from less than 0.01 lb/MWh for gas-fueled plants, to between 4 lb/MWh to less than 1 lb/MWh for coal-fired central station fossil plants utilizing an SO_2 control technology. The SO_2 output of these plants depends on the sulfur content of the fuel and the design of the SO_2 control system. At current sulfur levels for diesel fuels, SO_2 emissions are about 0.5 lb/MWh. For other pollutants, the DG technologies are significantly cleaner than the central station units.

In order to expand the use of DG while maintaining clean air, it will be necessary to encourage the employment of new DG technologies such as fuel cells, gas microturbines, photovoltaics, and wind, while simultaneously imposing mandatory pollution controls on reciprocating engines and combustion turbine units. Regulatory concerns include:

- Emissions from fossil-fueled DG.
- Operation during hours when ozone is peaking.
- Penetration/sheer numbers.
- Location in urban areas.
- Capacity under threshold for oversight.
- Lack of pre-certification.

Environmental issues that need to be addressed include:

- The local environmental impacts from DG technologies.
- The regional environmental impacts of DG technologies.
- The environmental life-cycle impacts of DG. While several DG technologies have little or no direct emissions, their life cycle emissions could be significant.
- The technologies and emission controls that are needed to make air emissions from DG as clean as those from central station power plants.
- The environmental tradeoff between using DG or the continued use of central power plants.

While the states have regulatory authority over motor vehicles and other mobile sources such as non-road engines, local air districts regulate stationary sources, including distributed generation. Some states are implementing new regulations restricting the amount of emissions allowed from DG units that are smaller than local air district permitting thresholds. The emissions rule seeks to improve the emission profiles of DG technologies so that they meet or exceed the emission profiles of state-of-the art central station power plants.

3.3 PERMITTING ISSUES

The following actions with respect to air emissions permitting for DG projects also need to be addressed:

- Develop uniform, achievable national air emission standards for DG.
- Provide credit for CHP in air quality permitting.
- Provide credit for avoided or offset emissions in air quality permitting.
- Apply market-based regulatory structures such as emission trading programs in a manner that will allow DG participation.
- Be emissions-based and technology-neutral, allowing low-NOx diesel engines to compete on the basis of emissions performance, instead of configuration, which could arbitrarily exclude diesel engines based on past performance.

3.4 POLICY ISSUES

The following policy issues/reforms would be beneficial in achieving DG's potential:

- Uniform national interconnection standards for DG.
- National energy efficiency and emission standards for DG.
- State DG policies.

3.5 GAPS IN THE KNOWLEDGE BASE

To determine the impact of deploying distributed generation, the SCNG is planning to perform a study. The objective of the study will be to quantify changes in emission rates and air quality given various mixes of central and distributed power generation technologies. The critical and most difficult question this study must address is:

"How will new DG fit into the future mix of new and existing power generators and what will be the emissions impact?"

To answer this question properly, one should use an electricity capacity dispatch model to see how DG operates in the dispatch mix for a given region and which generation/emissions are displaced. Parsons has developed such a model for NETL named the Government Energy Market Segment Evaluation Tool or GEMSET. A study using this model can evaluate the impact on emissions of predicted levels of market penetration by DG technologies.

Establishing the economic and environmental merits of distributed generation requires the hour-by-hour dispatch of both the central station fleet and the distributed generation fleet. This is the only way to assess the central station unit capacity factor and distributed generation unit capacity factor. Distributed generation is used whenever the delivered cost of central generation power is higher than self-production from distributed generation.

To establish the incursion of different levels of distributed generation, the GEMSET models developed for NETL could be used to establish the study baseline: the actual hour-by-hour prices and cost thresholds in various regions.

The study would use the actual baseline data for year 2002: the actual year 2002 hour-by-hour demand profile, fuel price profile, and actual day-ahead electricity costs. PJM is chosen as the focus region; this region is the largest control region in the world, the information is readily available and credibly established, and PJM is viewed as the model for how future competitive markets should be designed in the U.S. Distributed generation incursion studies variations and sensitivities would be assessed in detail in PJM against this baseline.

The study would model increased incursions of distributed generation into this market, displacing the central generation fleet. This is done by modeling a potential fleet of distributed generation equipment, and dispatching it based upon its economics compared with the hour-by-hour prices of the central fleet in the region. The distributed generation units would displace the least effective central station fleet units first, and depending on the level of distributed generation incursion, would displace more and more of the higher production cost central station units.

The environmental emissions and CO_2 expectation of the central station fleet would be drawn from their heat rates, the capacity factor from the above GEMSET dispatch analysis, and plant CEMS data from the EPA databases. The emissions expectation from the (increasing incursion) distributed generation fleet will be synthesized from presumed emissions rates for the proposed distributed generation equipment, the distributed generation unit heat rates and fuel characteristics, and the capacity factor from the above dispatch analysis. This assessment will be prepared for every hour of the year for every unit in the system (central and distributed generation), so seasonal expectations and trends can be analyzed. While PJM would be used for the screening, and be the source of multiple scenarios, the other regions could also be evaluated, depending upon the funding available to support this study.

4. RELEVANT DATA FOR THE PROPOSED STUDY

Several studies similar to the proposed study have been performed and the reports are included in these search results. Several of the most significant ones are listed in Table 1, beginning on page 9. The major conclusion that can be made after reviewing the results of this search is that distributed generation technologies are evolving rapidly, and while there have been significant studies performed and a large quantity of data developed, many aspects of this issue are worthy of further study or refinement.

There are several reports and databases that contain data relevant to the proposed study. The most significant of these are listed in Table 2, beginning on page 15.

Several models have been developed that could be useful in the proposed study; the most significant ones are also listed in Table 2. Most of the modeling is developed for market evaluation or to analyze grid effects, but many also include environmental features.

GEMSET is a system of models and databases that enable competitive evaluation of electric power generation plants in a connected system or grid. The GEMSET analyses have evaluated several utility generation pools in the continental United States to define the dispatch order and electricity cost-duration area for each pool. The system models hour-by-hour dispatch and has powerful forecast capability for a range of possible future circumstances. Each evaluation uses plant data from current databases to predict generation costs for every generating unit in the study region. It would be possible to insert a new plant or series of units with defined characteristics (heat rate, historical or forecast fuel costs based on current spot or forward pricing, emissions) to determine its probability of dispatch, capacity factor, and revenue stream. The impact on system wide emissions can also be estimated.

Many of the items that were found had the complete text available in electronic format. This text was captured and stored in Adobe PDF files and included on the CD deliverable. A list of all the text files is also included. The files were named with the title of the item truncated to 64 characters as needed. Also, six downloadable databases and one model are included in the original Excel and Access formats on the CD.

Due to the ever-changing and ever-expanding nature of the Internet, this survey is not comprehensive, but is extensive. Additional reports have been generated containing all the information located; and these are included with this summary on the CD deliverable. The reports are sorted by types of information and ranked with those considered to be the most useful listed first. The most applicable information found is summarized in the following tables. In the course of this survey, several organizations, web sites, and publications that seem very applicable to the future studies were noted; they are also included in the database.

Table 1
Titles, Abstracts, and Conclusions of Similar Studies

Study Title	Abstract	Conclusion
Distributed Energy and Air Emissions: A Wild Card for the Distributed Energy Market Date: July 2001 By: PRIMEN For: Members	Environmental regulations will shape markets for distributed energy for several years to come. As perceptions of an energy supply crisis sharpen, many utilities, state authorities, and entrepreneurs seek to use distributed energy units — and especially existing diesel generators — to boost electric generating capacity during supply crunches. These efforts have led some regulators to ease emission requirements and allow units permitted as emergency generators to run more often and during preblackout conditions.	Clearly, accumulating successful field experience with microturbines and advanced turbine systems (ATSs) would have an impact, primarily by convincing regulators that distributed energy operators could meet lower emission standards. Conversely, failure of the fuel cell market to develop as predicted in the media would have a countervailing effect, perhaps convincing regulators to loosen standards.
The Distributed Generation Puzzle: Piecing It Together Date: Apr 2000 By: Nadine Lihach For: Power Engineering	Discusses the implication of distributed generation (DG) for the power industry in the United States. Applications of DG; Benefits from DG technologies; Problems associated with the use of DG.	Without question, important issues affecting distributed generation are still up in the air. These issues—technology, economics and system interconnection—are real, and those in the industry are right to circle them cautiously. But it's also true that ready or not, distributed generation is arriving, swept forward by a real need for reliable, on-site power.
Will Increasing the Use of Distributed Generation Cause Brownouts in Air Quality? Date: Feb 2002 By: Judith M. Katz For: EPA	Peak load days most often occur in the hot summer months and may correspond with Ozone alert days - a bad time for NOx emissions and diesel generators. In order to expand the use of DG while maintaining clean air it will be necessary to encourage the employment of new DG technologies such as fuel cells, gas microturbines, photovoltaic and wind, while simultaneously imposing mandatory pollution controls on diesel units.	In order to expand the use of DG while maintaining clean air it will be necessary to encourage the employment of new DG technologies such as fuel cells, gas microturbines, photovoltaic and wind, while simultaneously imposing mandatory pollution controls on diesel units.
Encouraging distributed generation of power that improves air quality: can we have our cake and eat it too? Date: July 2002 By: Allison, Juliann Emmons; Lents, Jim For: EPA	Evaluates the governance structure responsible for regulating energy and environmental policy in the U.S. Categories of air pollution; Analysis of the electricity generation process with heat recovery; Approach for ensuring greater air quality.	Citation only found. Complete Report available in Energy Policy, Jul2002, Vol. 30 Issue 9, p737, 16p, 5 charts, 1 diagram, 11 graphs

Study Title	Abstract	Conclusion
Air Pollution Emission Impacts Associated with Economic Market Potential of Distributed Generation in California Date: June 2000 By: Ianucci, Eyer, Horgan, Cibulka For: California Air Resources Board	This study evaluates the net air emissions effects from the potential use of cost-effective distributed generation (DG) in California. The primary objectives of the study are, first, to estimate the economic market potential for distributed generation, and second, to determine the resulting air emissions given that level of deployment. The ultimate goal is to provide regulators and policymakers with information that will contribute to the development of strategies and policies regarding distributed generation.	Distributed generation technology continues to advance and market applications expand. Microturbines have been developed whose size matches commercial customers very well and whose emissions are promising. Recent residential fuel cell technology announcements may accelerate their market entry, either for individual residences, multiple residence buildings or in microgrids. Power quality issues and reliability for critical loads may add value to distributed generation installations and hence accelerate market entry. Some real-world market factors may now be ready for inclusion or refinement, such as exit fees, standby charges or interconnection costs for customer owned distributed generation; similarly the real availability of natural gas to candidate sites, costs for gas connection, and firmness of service may warrant further analysis.
Assessment of Distributed Generation Technology Applications Date: Feb 2001 By: Resource Dynamics Corporation For: Maine Public Utilities Commission	Distributed generation (DG) technologies can provide energy solutions to some customers that are more cost-effective, more environmentally friendly, or provide higher power quality or reliability than conventional solutions. Understanding the wide variety of DG options available in today's changing electric markets can be daunting. Some of these DG technologies offer high efficiency, resulting in low fuel costs, but emit a fair amount of pollutants (CO and NOx); others are environmentally clean but are not currently cost-effective. Still others are well suited for peaking applications but lack durability for continuous output. With so much to consider, it is often difficult for decision makers to determine which technology is best suited to meet their specific energy needs. This report explores DG technology applications and compares and contrasts them with one another. With this overview, current users and potential consumers of these energy products will better understand potential DG technology solutions."	This report analyzes various distributed generation technologies and presents a Matrix of the assessment results containing price and performance parameters for each commercial and near commercial technology. These tables provide data on equipment performance, maintenance, siting and environmental issues, economics, and generation costs

Study Title	Abstract	Conclusion
Residential Distributed Energy - Will it Expand Beyond the Standby Market? Date: Nov 2002 By: Virinder Singh For: Renewable Energy Policy Project	Residential distributed energy (DE) systems for single-family homes have always been the holy grail of DE product developers — a mass market product with millions of potential sales. Yet, the smaller system sizes for this market have also presented the toughest economic and technical hurdles. The only DE products that have shown real penetration into homes in North America have been standby systems, though there is a growing interest and market for PVs, particularly in California. Residential energy users also say they're interested in onsite generation systems that can provide baseload power, but their interest rapidly diminishes once they learn what the price for such a system would be. This Perspective looks at the evolution and growth of the residential DE market in the last 2 years, and how it might unfold in the next 3-5 years.	In looking at the future development of this market, a few key drivers can be monitored. Demand in this market is extremely sensitive to electric reliability problems. The strong demand resulting from the California crisis is a case in point, but if regional electric markets return to a period of quiescence without headlines of reliability problems or price increases, demand may soften and the enthusiasm for this market will wane.
Distributed Generation: Technologies, Opportunities, and Participants - 3rd Edition Date: 2003 By: Energy Info Source For: publication	The 3rd Edition of Energy Info Source's Distributed Generation: Technologies, Opportunities, and Participants Report is a comprehensive 135-page study of the Distributed Generation (DG) industry. The report takes a wide-ranging look at the current and future state of DG and both individually and collectively addresses the technologies of Microturbines, Reciprocating Engines, Stirling Engines, Fuel Cells, Photovoltaics, Concentrating Solar, and Wind.	In conclusion, DG may play an important role in shaping the newly restructured energy market. Three forces are shaping the way it will emerge: utilities, customers and regulatory agents. Often overlapping, these forces will determine the outcome of DG. Decision-makers in the industry can use this report as an analytical instrument to assist them in evaluating DG's trajectory in emerging markets. Designing a successful competitive strategy in the evolving energy industry will ultimately include distributed generation.

Study Title	Abstract	Conclusion
The Impact of Air Quality Regulations on Distributed Generation Date: Oct 2002 By: Joel Bluestein, Susan Horgan, M. Monika Eldridge NREL For: DOE	Relatively small projects for generating electrical power at or near the point of use-distributed generation (DG) -offer unique opportunities for enhancing the U.S. electric system. This report finds that current air quality regulatory practices are inappropriately inhibiting the development of DG through a failure to recognize the environmental benefits offered by DG or by imposing requirements designed for larger systems that are not appropriate to DG systems. The report recommends that air quality regulation be made more efficient and appropriate for DG by establishing national standards for DG equipment. This report also recommends that DG projects be evaluated on a "net" emissions basis by being given credit for any emission sources that they displace. Air quality regulation should also recognize and account for the benefits of combined heat and power (CHP).	DG has the potential to provide energy, environmental, and commercial benefits in a variety of applications in which the central generation grid does not and cannot provide the same efficiency, reliability, or customization to user needs. This study recommends specific changes in the structure of existing air quality regulation that could prevent unnecessary constraints on the development and expansion of distributed generation and allow the realization of the potential environmental benefits of these technologies. New technologies, new energy regulatory structures, changing user needs, and the continuing penetration of modern electronic devices into our infrastructure are creating these opportunities. To achieve these potential benefits, however, environmental regulation must also keep pace with changing technology, markets, and energy regulations.
Clean Distributed Generation: Policy Options to Promote Clean Air and Reliability Date: Feb 2001 By: Edward M. Meyers and Mannshya Grace Hu For: electricity-online	To our knowledge, humans are the only creatures that do not measure their collective success by how well they adapt to their environment. Gross domestic product, the Dow or Nasdaq, or maybe our timeless structures, art, music, and novels are indicators of success, yet we too easily accept a filthy river, orange air, and even atmospheric alteration as byproducts of progress. In contrast, any tiger or elephant knows that if its habitat is endangered, then it's in big trouble.	Electric power generation is responsible for about 40 percent of carbon dioxide emissions, a primary contributor to climate change. Carbon emissions at present are not regulated by the U.S. Environmental Protection Agency or anyone else. Despite this regulatory neglect, a quiet evolution is proceeding in electricity generation these days. It looks like we now have a chance to modify not only the way we supply power but also, at least in significant part, the way we humans successfully restore our and the other critters' environment.

Study Title	Abstract	Conclusion
Distributed Energy Markets Expanding at Time of Uncertainty Date: Nov 2002 By: Scott Sklar For: Energy Pulse	As states have begun a march towards on-and-off deregulation or reregulation, the US market has picked-up for distributed generation in a big way. Prior, the international markets have been the mainstay for distributed generation technologies from diesels and reciprocating engines to battery banks and photovoltaics. The international markets for distributed generation have been telecommunications, (primarily cellular and redundant systems), uninterruptible power systems for banking and government, and back-up systems for the tourism industries. But as the U.S. grid begins to age and regulatory swings slow investment into transmission and distribution infrastructure expansion and upgrades, distributed generation has taken on new significance in the U.S. domestic marketplace. The electric utility industry primarily relies on the traditional distributed generation solutions utilizing reciprocating engines with some experimentation in microturbines, fuel cells and photovoltaics. Basic prime drivers for distributed generation vary.	There is still a long way to go in removing regulatory blockages, corporate wariness within the utility sector, and large needs for investment in the for distributed generation industries for scaling- up manufacturing and delivery systems. But the cork is out of the bottle, and the distributed generation genie is out the door. And the marketplace has been quite dynamic and should become more so.
The New Economic Landscape for Distributed Energy Date: June 2002 By: Jim Fay, Michael Casey For: PRIMEN	The restructuring of the North American electric power industry continues to affect how distributed energy (DE) developers determine their projects' economic competitiveness. The combination of wholesale power markets opening up and retail energy users' new options for responding to wholesale power price signals is likely to drive economic decisions about installing DE and choosing DE applications.	In the ideal case, new DE investments or operational strategies would be evaluated against the economic landscape, anticipating the impact of current changes planned. However, it's still early in the development of competitive wholesale markets to know just how the structure — much less the pricing — of the market will evolve. We can only use what we observe about the market today and our knowledge of how economic and regulatory systems will react to anticipate what the future market will look like. Nonetheless, we anticipate that an open competitive market will find new substitutes, in addition to DE, for the very high peak prices observed in wholesale markets today. These substitutes will, in turn, bring the prices down. If the continued evolution of wholesale markets mitigates price spikes, the economic savings opportunity for DE also disappears.

Study Title	Abstract	Conclusion
THE GOOD, THE BAD, AND THE OTHER Public Health and the Future of Distributed Generation Date: Oct 2001 By: Todd Campbell, et al. For: California Public Interest Research Group Charitable Trust Coalition for Clean Air	The debate over California's energy future has focused attention on a growing sector of the energy market. Homeowners and businesses are generating electrical energy near the place it is used as an alternative or supplement to the statewide power grid. Known as distributed generation (DG), this family of technologies holds great promise for locally controlled power generation. But continued reliance on polluting technologies poses a threat to public health. As elected officials wrestle with solutions to the short-term energy crisis and as all policy makers strive to promote energy efficiency, state agencies are working to assure that clean, reliable technologies are available to encourage greater energy generation flexibility.	Distributed generation is here to stay and is likely to expand rapidly in the coming years. This is both an opportunity and a risk for public health in California. Clean DG options have the potential to greatly reduce dangerous emissions from electricity production, but the most common DG technology — the diesel generator — is even more polluting than the leading technologies of large central power plants. To ensure that public health is protected and that new technologies to reduce pollution are encouraged, distributed generation policy should be based on several principles listed in this report.
Performance and Cost Trajectories of Clean Distributed Generation Technologies Date: May 2002 By: Energy Nexus Group For: The Energy Foundation	This study for the Energy Foundation assessed the technical and economic impacts of the CARB Emission Certifications Regulation that asserts the eventual need for DG technologies to be as clean as a modern central station combined cycle plant. The analysis evaluated cost, performance and emissions ranges for 2003 and project scenario trajectories ranges for 2007 and 2012	A detailed data set was developed for each of the fifteen technologies and each of the three scenarios and timeframes. This data set consisted of cost, performance, and emissions of uncontrolled systems and similar data for the controlled systems with after treatment or advanced combustors. This data set was then used with the same economic assumptions defined above to calculate CHP life cycle costs. The emissions data was compared to the CARB regulation to determine if the system would satisfy these requirements in both the electric-only and CHP applications. Exhibit 13 summarizes the trajectories for NOx emissions. Systems that meet the CARB levels are shown with a check mark. The projected emission levels are shown for those that do not meet CARB. Each of the four technology groupings are reviewed and technical opportunities to achieve improvements in performance, cost and emissions are discussed.

Table 2
Databases, Models, and Reports Containing Significant Information for Use in Future Studies

Title Type of Item	Publishing Organization	Description
Annual Energy Outlook 2003 -- Report	DOE	The Annual Energy Outlook 2003 (AEO2003) presents midterm forecasts of energy supply, demand, and prices through 2025 prepared by the Energy Information Administration (EIA). The projections are based on results from EIA's National Energy Modeling System (NEMS).
Competitive Power Market Analysis for WSCC, ERCOT, MAIN, ECAR, NPCC, SPP, FRCC, SERC, MAPP and MAAC Regions -- Report	LCG Consulting	As the volume of electricity traded in a competitive market environment increases, the volatility of electricity prices follows suit, and the premium paid for price security is likely to increase. These factors have a direct implication on the value of utility's generation resources. LCG consulting has taken the initiative to make available useful subscription-based information on electricity price forecasts to utilities, power marketers, buyers, and others. These forecasts are provided at various levels (daily, weekly, monthly, yearly) for the different companies and zones in the WSCC, ERCOT, MAIN, ECAR, NPCC, FRCC, SPP, SERC, MAPP, and MAAC regions. The futures price index is the weighted average price of megawatt hour and the index is quoted in dollars per megawatt hour.
Emissions from Distributed Generation -- Presentation	Resource Dynamics Corporation	A summary of air emissions from DG equipment presented to the California Energy Commission on April 20, 2000, by Sheryl Carter.
BNA Environment & Safety Library	BNA, Inc.	This powerful, easy-to-use, continuously updated research collection of federal and state laws, regs, documents, and compliance tools is the only source you need for environment and safety information.
Heavy-Duty Diesel Emissions Database	Environmental Protection Agency	The data in this Excel Spreadsheet file was used in the development of a model correlating diesel fuel properties with emissions of regulated pollutants. The model was developed by the Environmental Protection Agency using resources at Southwest Research Institute. This version of the database includes all repeat data, and all test cycle data that was rejected in this analyses. Additional information about the project can be found at: http://www.epa.gov/otaq/models/analysis.htm.
Database -- EGRID The Emissions & Generation Resource Integrated Database	EPA	A comprehensive source of data on the environmental characteristics of all electric power generated in the United States. An integration of 24 different federal data sources, E-GRID2000 provides information on air pollutant emissions and resource mix for individual power plants, generating companies, states, and regions of the power grid. The data are expressed in terms that allow direct comparison of the environmental attributes of electricity generation at any level.
BUGS 1 -- Database of Public Back-Up Generators (BUGS) in California Database	CEC DER	This database was assembled largely from information received from all the air districts in California except the Bay Area AQMD, with supplemental information supplied by the California Department of Corrections, The Office of Energy Assessments of the California Department of General Services, PG&E, Silicon Valley Power, and a major telecommunications company operating in the state. The user of this inventory needs to be aware of several features and assumptions made in assembling elements of the database, as well as several known limitations.

Title **Type of Item**	**Publishing Organization**	**Description**
BUGS 2 -- Database of Portable Back-Up Generators (BUGS) in California	CEC DER	This database was extracted from the California Air Resources Board (ARB) database of portable diesel engines permitted for operation in California. Only engines used to power generators with generating capacity greater than 300 kW are included. This list is as of May 2001.
Database -- Air Facility Subsystem (AFS)	AIRS Facility Subsystem (OECA): Office of Enforcement and Compliance Assurance	The Air Facility Subsystem (AFS) contains compliance data and permit data for stationary sources of air pollution regulated by the U.S. EPA, and state and local air pollution agencies. This information is used by the environmental regulatory community to track the compliance status of point sources with various programs regulated under the Clean Air Act. Only Data Dictionary captured.
Form EIA-860B Database Annual Electric Generator -- Nonutility	EIA	This is the nonutility generating facility data file that includes such information as company, facility, unit ID, facility nameplate capacity, generator nameplate capacity, unit type, prime mover, energy source, qualifying facility status, NAICS codes, consump tion, heat content, facility generation, generator generation, purchases, sales to utility, facility use, environmental information, generator status, operational status, on-line date. Data source is survey EIA-860B: "Annual Electric Generator Report - Nonutility." The data are compressed into a self-extracting (.exe) zip file that expands into 7 DBF files and an ASCII layout file (Layout.txt). Includes company, facility, unit, nameplate capacity, unit type, prime mover, energy source, qualifying facility status, NAICS codes, consumption, heat content, generation, purchases and sales, generator status, and on-line date for nonutility generators.
Government Energy Market Segment Evaluation Tool (GEMSET) -- Tools to Assess the U.S. Market	Parsons	The GEMSET product promotes the reasoned evaluation of the economic and environmental prospects of fossil electric power generation technologies in the various regions of the United States. The evaluations and tools in the GEMSET product allow assessment of the existing plant investment and return conditions throughout the U.S. These tools and assessments allow the investigation of different environmental, demand, and fuel price scenarios that might exist in the various regions, and gives reasoned projections of where these circumstances might be in the future.
Integrated Planning Model (IPM)	ICF Consulting	The Integrated Planning Model (IPM®) is the ultimate tool for evaluating all facets of the electric power markets. Since IPM's inception in the 1970s, ICF Consulting has utilized IPM for all major analyses of the power markets and to guide clients in making critical business decisions.
MAISY Utility Service Area DG Policy Models	Jackson Associates	Basic Utility Service Area DG Policy Models provide an assessment of the current economic potential of engines, microturbines, turbines and fuel cells for current customers in every utility service area. Forty DG technology characterizations are evaluated in the models based on manufacturer and industry data. A complete assessment of DG potential applications is conducted including peak clipping applications, baseload systems, waste heat utilization for space heating, water heating, and absorption air conditioners.
The National Energy Modeling System	DOE	The National Energy Modeling System: An Overview 2003 provides a summary description of the National Energy Modeling System (NEMS), which was used to generate the forecasts of energy production, demand, imports, and prices through the year 2025 for the Annual Energy Outlook 2003 (AEO2003).